P.S.

THE UNIVERSITY OF NEW SOUTH WALES

Examination

Session 1/2001

COMP3411

Artificial Intelligence

- Time allowed: **2 hours (120 marks in total)**
- Total number of questions: **8**
- Answer **all** questions
- The questions are **not** of equal value
- Answer *each* question in a **separate** book
- This paper can be retained by the candidate

ANSWERS MUST BE WRITTEN IN INK. EXCEPT WHERE THEY ARE EXPRESSLY REQUIRED, PENCILS MAY BE USED ONLY FOR DRAWING, SKETCHING OR GRAPHICAL WORK.

Question 1 [8 Marks]

Agents:

Explain the difference between a performance measure and a utility function.

Do not use more than four sentences for your answer.

Question 2 [18 Marks]

Search:

A) **[6 marks]**

Consider the blocks world in figure 1. The gripper can only pick up a single block that is on the top of a stack or on the floor.

The task is to transform a given configuration of the 8 blocks into another configuration, such as the two example configurations in figure 1. The cost function should be the number of block moves.

Explain what operators you would choose for your search.

B) **[4 marks]**

For uninformed search, which strategy is best suited: depth first search, breadth first search or iterative deepening?

Justify your answer.

HINT: Your answer may depend on the chosen actions.

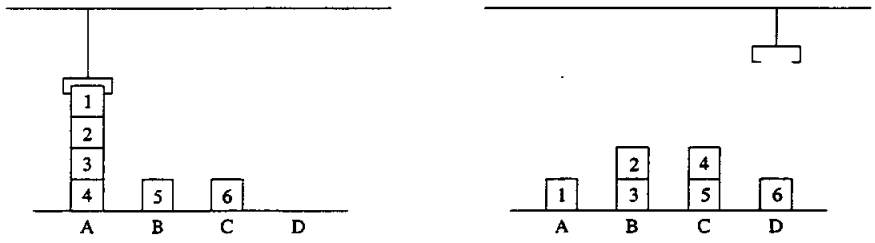

Figure 1: Blocks world: There are 4 places 'A', 'B', 'C', 'D' to place or stack blocks. The six blocks can be lifted and placed using the gripper. A problem instance is given by an initial state (e.g. the left configuration) and a goal state (e.g. the right configuration). The location of the gripper has no relevance for identifying the goal state, i.e. the gripper can be anywhere.

C) **[4 marks]**

Informed Search: Explain the criterion for a heuristic to be an admissible heuristic for A^*.

D) **[4 marks]**

Give an admissible heuristic for the blocks world problem above (which gives non-zero values for some search states).

Question 3 [10 Marks]

Game Playing:

A) **[2 marks]**

What is an evaluation function in the field of game playing in artificial intelligence?

B) **[4 marks]**

Draw a (binary) Minimax search tree of depth 4 (consider the root node to be at depth 0). Show what values are assigned to each node.

Choose an evaluation of the leaf nodes so that different values are used and that it is clearly demonstrated how the Minimax evaluation works for the rest of the tree.

C) **[4 marks]**

Explain how α-β search works?

Why and how does its performance depend on the order in which you evaluate the successor nodes of a given node?

Question 4 [12 Marks]

Logic:

A) **[6 marks]**

Consider the following sentence in first-order logic:

$$\forall x \forall z \exists y \; Pretty(x) \wedge Parent(z, x) \Rightarrow (Happy(z) \wedge Happy(Lover(x))).$$

Decide for each symbol (apart from '$\forall$', '$\exists$', '$\Rightarrow$', '(', ')', '$\wedge$', '$\vee$', '$\neg$') in the sentence, whether it is a constant, a variable, a function symbol or a predicate symbol.

B) **[6 marks]**

Give a translation of the above sentence into English.

Question 5 [15 Marks]

Reasoning: Consider the following knowledge base:

$\forall x, y, z \; Likes(x, y) \wedge Likes(y, z) \Rightarrow Likes(x, z).$
$\exists x \; Likes(Sheep, x).$
$Likes(Sheep, Cabbage).$
$Likes(Wolf, Sheep).$

A) **[5 marks]**

Convert all sentences into their clausal form.

B) **[10 marks]**

Prove that the sentence

$$Likes(Wolf, Cabbage).$$

is logically entailed by the knowledge base using resolution. Draw the refutation graph and provide all substitution operators σ for each resolution step you use.

Question 6 [20 Marks]

PROLOG: Consider the following piece of PROLOG code:

```
p(X, [X|Y], Y).
p(X, [W|Y], [W|Z]) :-
        p(X, Y, Z).
```

A) **[8 marks]**

What will be the output for the following input?

```
p(X, [1, 2, 3], Y)?
```

B) **[12 marks]**

Write a Prolog program that will produce all permutations of a list on backtracking. If you wish, you may use the program in part (A).

For example, the query,

```
perm([a, b, c], X)?
```

should output

```
X = [a, b, c]
X = [b, a, c]
...
```

Hint: The program is very short if you have the right idea.

Question 7 [17 Marks]

Natural Language Processing:

A) **[5 marks]**

Consider the following formal grammar:

1. S → NP | NP VP
2. NP → Noun | Article Noun | PP
3. VP → Verb | VP NP
4. PP → I | you | he | she | it
5. Article → a | the
6. Noun → car | house | gift
7. Verb → know | like | own | see

Which of the following sentences are grammatical and which are ungrammatical? Provide for each grammatical sentence its parse tree.

i) I like the house
ii) the house likes see
iii) he own car
iv) you
v) she see own the house

B) **[6 marks]**

Amend the above grammar such that the following sentence is grammatical:

I like the house you own

List all existing rules you wish to change as well as any rule you want to add and any rule you want to drop.

Provide the parse tree for the sentence.

C) **[6 marks]**

What distinguishes a *Definite Clause Grammar* from a *Context Free Grammar*?

Question 8 [20 Marks]

Machine Learning:

Given the following training data construct a decision tree from it for the class attribute *sick* using the entropy (information gain) measure.

Example no.	colour of face	headache	fever	has an exam today	sick
1	green	yes	yes	no	yes
2	white	no	yes	no	yes
3	normal	no	no	yes	no
4	green	yes	yes	yes	yes
5	white	no	yes	yes	no

A) **[12 marks]**

Show your calculations for your decisions to pick a particular attribute to split on for all decision nodes of your tree.

B) **[4 marks]**

While your resulting tree should classify all seen cases correctly, it may classify some unseen patients incorrectly. Give two possible reasons why this can be the case.

C) **[4 marks]**

How can you increase your confidence in the correct classification by the decision tree?